

National Aeronautics and
Space Administration



EXPLORE SOLAR SYSTEM & BEYOND

Planetary Science Division Technology Overview

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Mercury Exploration Assessment Group (MExAG)

The background of the slide is a dark blue gradient. On the left side, there is a vertical strip of space imagery. From top to bottom, it shows a yellow planet with rings (Saturn), a reddish-brown planet (Mars), a grey cratered moon, and the blue and white horizon of Earth. A bright yellow sun is visible at the bottom left of this strip. The word "OUTLINE" is written in large, light blue, sans-serif capital letters in the upper right quadrant of the slide.

OUTLINE

- Technology Development in Planetary Science Division
- Technology and Science working together
- Exciting Technologies for Future Planetary Missions

The background of the slide is a dark blue space-themed image. On the left side, there is a vertical strip showing a bright yellow sun at the bottom, followed by the blue and white horizon of Earth, a grey cratered moon, a reddish-brown Mars, and a yellow Saturn with its rings at the top. The rest of the slide has a solid dark blue background.

PLANETARY EXPLORATION SCIENCE TECHNOLOGY OFFICE (PESTO) IS CHARTED TO:

- Recommend strategic technology investments to Planetary Science Division (PSD)
- Manage PSD technologies until they are adopted by missions
- Promote technology infusion
- Foster coordinated technology investments across NASA
 - Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO)
 - Maturation of Instruments for Solar System Exploration (MatISSE)
 - Development and Advancement of Lunar Instrumentation (DALI)
 - Hot Operating Temperature Technology (HOTTech)
 - Concepts for Ocean Worlds Life Detection Technology (COLDTech)
 - Coordination work across SMD divisions, with STMD, and leveraging SBIRs and EPSCoR



TECHNOLOGY DEVELOPMENT PATH

PICASSO



MatISSE
DALI



Flight Instrument
CLPS, Simplex, Discovery, New
Frontiers, Flagship missions

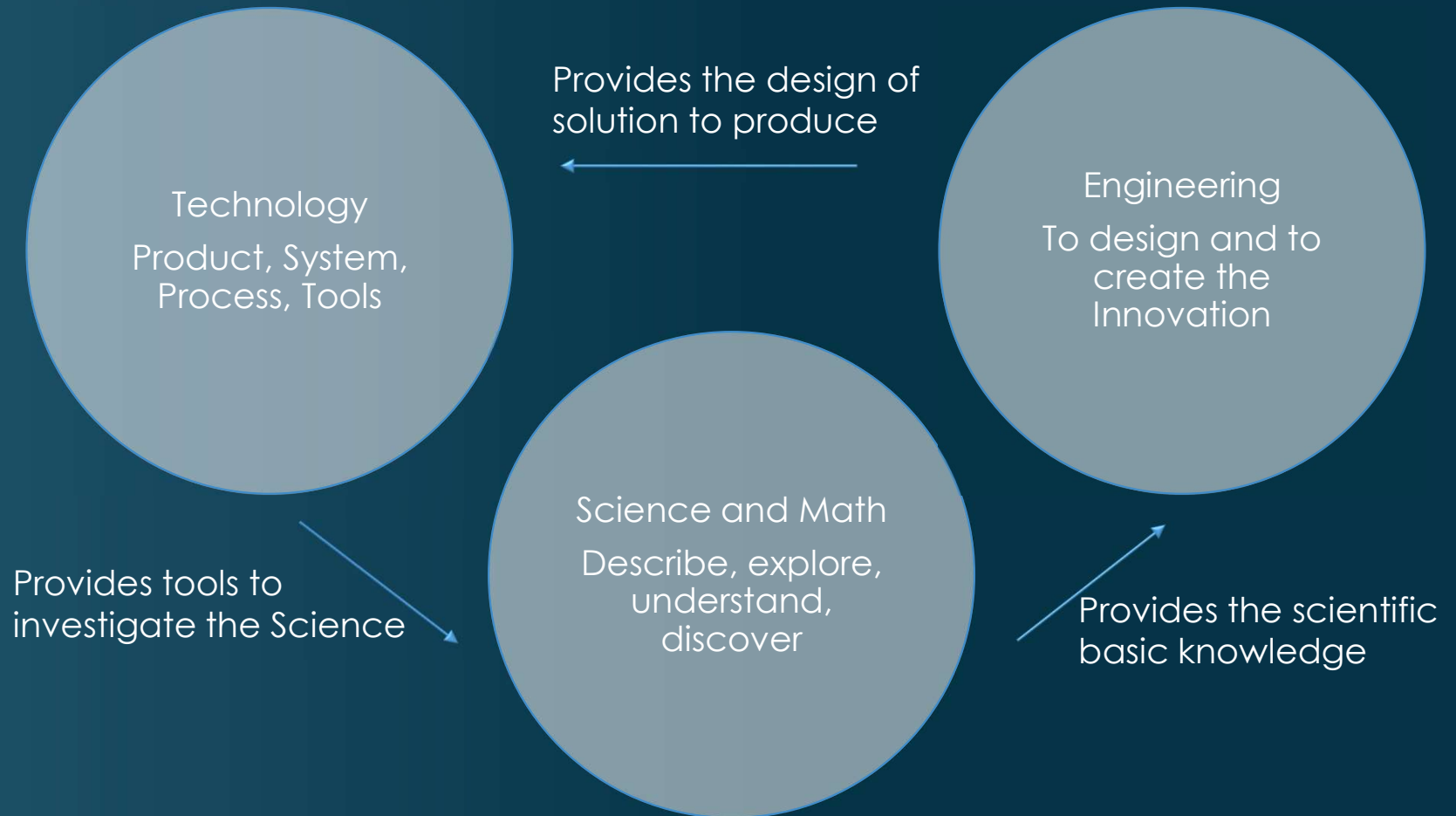
I have this crazy
idea
Initial: TRL 1-3

I can make it
work
Initial: TRL 4-6

How did we ever do
without it?
TRL ≥ 6

TRL Definitions can be found in: NPR 7123.1C Appendix E
(available at https://nodis3.gsfc.nasa.gov/main_lib.cfm)
<https://www1.grc.nasa.gov/space/pesto/>

STEM CONNECTIVITY



Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) Program

Typical Solicitation Timeline:

- ROSES solicitation release - February
- No Due Date (NoDD) – Proposals can be submitted anytime
- Step-1 or NOI - Not required
- Panel Reviews – Throughout the year

Solicitation Overview:

- PICASSO program supports the development of **spacecraft-based instrument hardware** that would enhance or enable the scientific return from future planetary missions, e.g., SIMPLEx, Discovery, New Frontiers, Mars Exploration, and other planetary programs, including those flown on commercial spacecraft.
 - **New proof-of-concept instruments, systems or components**, including sampling technologies, that significantly improve instrument measurement capabilities to address high priority science goals of planetary missions.
- PICASSO program objective is to **develop and mature low size, weight and power instruments or instrument technologies with entry Technology Readiness Level (TRL) 1-3**. TRL >4+ advancement is made through the MatISSE Program.

For examples of past PICASSO program funded instruments applicability to science goals and instrument type, see link: <https://www1.grc.nasa.gov/space/pesto/instrument-technologies-current/planetary-instrument-concepts-for-the-advancement-of-solar-system-observations-picasso/>

Typical budget/award	~ \$300K/year
Maximum award duration	3 years



Ice giants net flux radiometer focal plane assembly developed using PICASSO funding.

MATURATION OF INSTRUMENTS FOR SOLAR SYSTEM EXPLORATION (MatISSE) Program

Typical Solicitation Timeline (every EVEN year '20, '22, '24):

- ROSES Solicitation Release – February
- Step 1 Proposals Submitted – April
- Step 2 Proposals Submitted – July
- Panel Reviews – September

Typical budget/award	~ \$1.0M/year
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Maximum award duration	Up to four years
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Solicitation Overview:

- MatISSE supports the development of **spacecraft-based instruments** for use on **future planetary missions (all destinations except lunar)**
- The MatISSE program goal is to develop science instruments to the point where they may be **proposed to future flight opportunity announcements** (i.e. SIMPLEx, Discovery, New Frontiers, Mars Exploration, and other planetary programs, including those flown on commercial spacecraft) without additional technology development
 - MatISSE supports TRL maturation from **TRL 4 to TRL 6**
- MatISSE seeks to mature instruments that **support** Planetary Science Division's strategic goals and objectives

For examples of past MatISSE program funded instruments applicability to science goals and instrument type, see link:

<https://www1.grc.nasa.gov/space/pesto/instrument-technologies-current/maturation-of-instruments-for-solar-system-exploration-matisse/>



NASA Dragonfly:
The DraMS (mass spectrometer) and
DraGNS (Gamma-Ray and Neutron
Spectrometer) Instruments have heritage
from the MatISSE program

Development and Advancement of Lunar Instrumentation (DALI) Program

Typical Solicitation Timeline:

- ROSES Solicitation Release – February
- Step 1 Proposals Submitted – April
- Step 2 Proposals Submitted – June
- Panel Reviews – October

Typical budget/award	~ \$1.0M/year
Maximum award duration	4 years

Solicitation Overview:

- DALI supports the development of **spacecraft-based instruments** for use on **future lunar missions** including commercial ventures (i.e. CLPS).
 - The DALI program goal is to develop lunar science instruments to the point where they may be **proposed to future flight opportunity announcements** (i.e. PRISM) without additional technology development.
 - DALI generally supports TRL maturation from **TRL 4 to TRL 6**.
- DALI seeks to mature lunar science instruments that **support NASA's broader lunar exploration goals**.
 - Goals applicable to human exploration, in situ resource utilization, and lunar science.
 - All instrument types, including rover-based and orbital, are considered with specific interest in small, stationary lander instruments.

For examples of past DALI program funded instruments applicability to science goals and instrument type, see link: <https://www1.grc.nasa.gov/space/pesto/instrument-technologies-current/development-and-advancement-of-lunar-instrumentation-dali/>



Hot Operating Temperature Technology (HOTTech) Program

Last Solicitation Timeline:

- ROSES Solicitation Release – February 2021
- Step 1 Proposals Submitted – June 2021
- Step 2 Proposals Submitted – August 2021
- Panel Reviews – October 2021

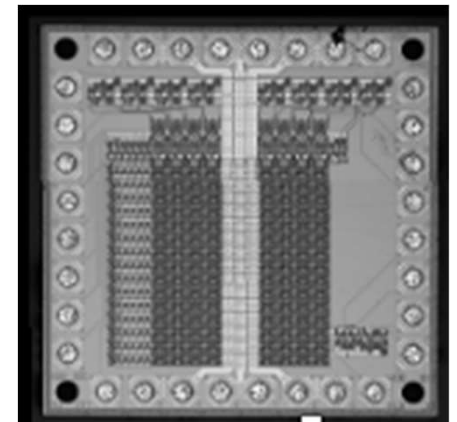
Solicitation Overview:

- HOTTech supports the advanced development of technologies for the robotic exploration of high-temperature environments such as the Venus surface, Mercury, or the deep atmosphere of Gas Giants
- The goal of the program is to develop and mature technologies that will enable, significantly enhance, or reduce technical risk for *in-situ* missions to high-temperature environments with temperatures of 500 Celsius for a period of at least 60 days
 - Radio Frequency (RF) Components or Systems (>100 MHz)
 - Power Transistors/Electronics (>1000 mA)
 - Passive Electronic Components (capacitors, inductors, resistors)
 - Low-Power Electrical Circuits (<1000 mW)
 - Actuators/Motors and associated Lubrication Systems
 - Energy Storage/Batteries/Power Harvesting
 - Sensors/Imaging Cameras
- Specific technology readiness levels (TRLs) were not prescribed in the last HOTTech solicitation

Typical budget/award	~ \$500K/year
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Maximum award duration	3 Years
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7 projects selected



SiC Memory Chip: 120-bit RAM
~1000 SiC JFETs 4.65 x 4.65 mm chip
32 I/O Bond pads

Concepts for Ocean Worlds Life Detection Technology (COLDTech) Program

Last Solicitation Timeline:

- ROSES Solicitation Release – February 2020
- Step 1 Proposals Submitted – December 2020
- Step 2 Proposals Submitted – February 2021
- Selection – April 2021

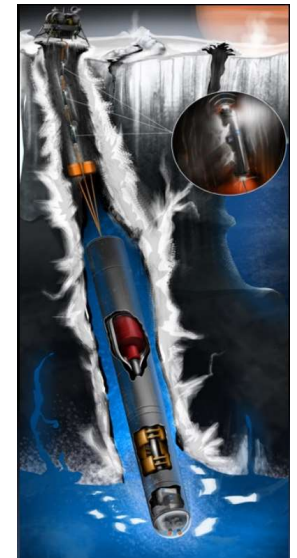
Typical budget/award	~ \$4M/year
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Maximum award duration	3 Years
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11 projects selected

Solicitation Overview:

- COLDTech supports the advanced development of spacecraft-based technology for surface and subsurface exploration of ocean worlds such as Europa and Enceladus to develop and reduce the technical risk of technology so that they may eventually be incorporated into future flight missions
- NASA had not specified the science objectives and the mission architecture for future ocean worlds missions at the time of solicitation. A driving requirement for any such a mission is the sampling strategy, particularly the depth from which a sample is acquired. Specific technologies sought for this COLDTech opportunity are:
 - Autonomy for landed operations
 - Technology to enable communication through many kilometers of ice thickness
 - Radiation-hard digital devices
- Specific technology readiness levels (TRLs) were not prescribed in the last HOTTech solicitation



Artist rendering of tethered optical fiber and acoustic communication on icy world, Image credits: Alexander Pawlusik, LERCIP Internship Program
NASA Glenn Research Center

EXCITING TECHNOLOGIES UNDER DEVELOPMENT



MatISSE

PICASSO

Volatile-sensing Array for Planetary Onsite Research (VAPOR)

- Develop instrument-on-chip for in situ chemical analysis for trace gases
- Enable unambiguous detection of species with mass interference (H_2O , CH_4 , NH_3)

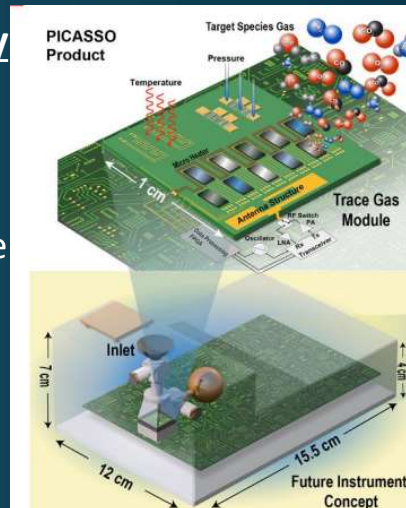


Image credits: NASA GSFC

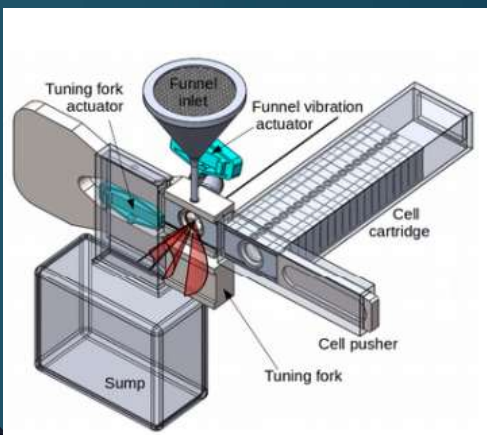


Image credits: SETI Institute

Seismometer to Investigate Interior Asteroid Structure (SIAS)

- Develop a very broad band (VBB) seismometer and penetrometer burial system to deploy seismometer
- Enable characterizing the structure and seismicity of an asteroid structure

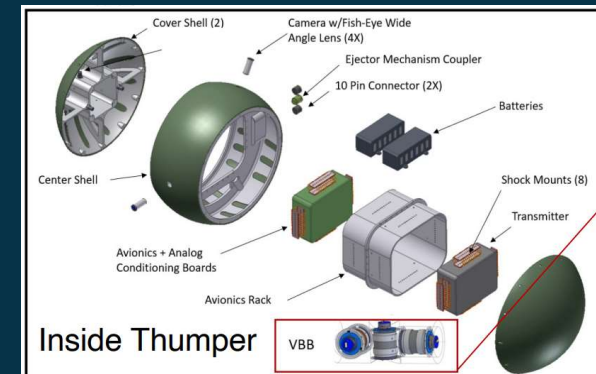
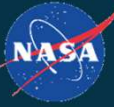


Image credits: University of Arizona

Micro-Sampling System for Mineralogical Instruments

- Develop micro-sampling system for deployment of X-Ray Diffraction/X-Ray Fluorescence for smaller rovers
- Enable quantitative soil mineralogy, document oxidation, establish limits for CO_2 levels

EXCITING TECHNOLOGIES UNDER DEVELOPMENT



COLDTech

PARTI Pucks

- Develop communications pucks for deployment behind cryobot during descent
- Provides backup communications using series of relay pucks
- Enable cryobots to assess habitability, water parameters/salinity, search evidence of life

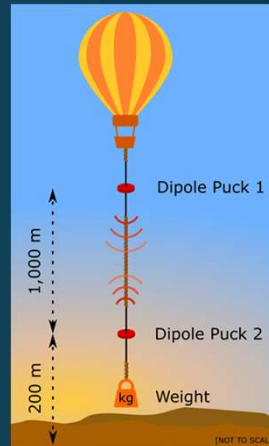


Image credits:
Stone Aerospace

Technology Developments for Sending Signals Through the Ice (STI)

- Develop tethered optical fiber and acoustic communication
- Enable search for evidence of life, assessment of habitability, surface and subsurface properties



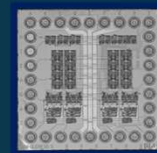
Image credits: Johns Hopkins U.

HOTTech

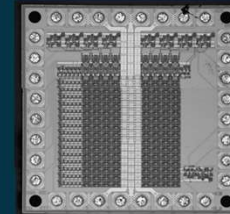
Silicon Carbide (SiC) JFET-R Integrated Circuits (ICs)

- Enable long duration missions to high temperature destinations
- Have demonstrated:
 - 1000's hours operation at 500 °C
 - Continuous operation during 60 day GEER test
- HOTTech-21 projects utilizing SiC JFET-R:
 - Non-volatile SiC Memory (NASA GRC)
 - Actuator/motor (Honeybee Robotics)
 - Seismometer development (NASA GRC)
 - UV Imager (General Electric Research)

SiC IC Gen 10



SiC IC Gen 11



SiC IC Gen 12

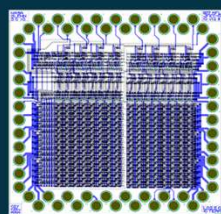


Image credits: NASA GRC

EXCITING TECHNOLOGIES UNDER DEVELOPMENT



HOTTech

Advanced Co-Based Nanocrystalline Soft Magnetics for Extreme Temperature Inductor Applications

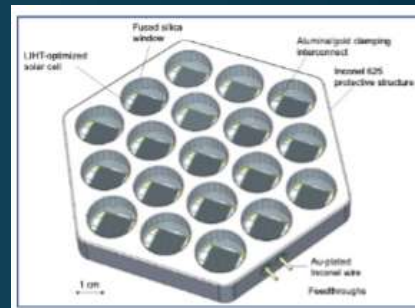
- Develop extreme temperature inductor
- Enable long duration missions to high temperature destinations



Cobalt-Based
Nanocomposite Core
Inductors
Image credits: University
of Pittsburgh

Venus Surface Solar Array

- Develop a solar array that would survive and operate efficiently
- Enable solar power up to 60 days, up to 500deg. C



Solar cells protected in containment structure
Image credit: Jet Propulsion Laboratory

High Temperature Transmitter for Venus Environment

- Develop a transmitter to work at 500 deg. C, 1500PSI
- Enable radar for remote sensing to determine geophysics details



Microfabricated vacuum triodes) and microwave high temperature passive components
Image credits: InnoSys Inc.



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